FLOOD INSURANCE STUDY

CITY OF PORT ANGELES, WASHINGTON
CLALLAM COUNTY

REVISED: SEPTEMBER 28, 1990

Federal Emergency Management Agency

COMMUNITY NUMBER - 530023

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. The Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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FLOOD INSURANCE STUDY
CITY OF PORT ANGELES, CLALLAM COUNTY, WASHINGTON

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the City of Port Angeles, Clallam County, Washington. This information will be used by the City of Port Angeles to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Coordination

Community base map selection and the identification of streams requiring detailed study were done in meetings attended by personnel of the U.S. Geological Survey (USGS), the FIA, and the City of Port Angeles in February 1976.

During the course of the work by the USGS, flood elevations, flood boundaries, and floodway delineations were reviewed with community officials.

The scope of work for the restudy of coastal areas east of N Street in Port Angeles was determined in July 1986 by representatives of the Federal Emergency Management Agency (FEMA) and representatives of the City of Port Angeles. During the course of the coastal restudy between August 1988 and July 1989, several meetings were held between CH2M Hill, Inc., the study contractor and representatives of FEMA to clarify the objectives of the scope of work.

A final consultation coordination meeting was held on February 14, 1990, and attended by representatives of the City, FEMA, and the study contractor.

1.3 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by the USGS, for the FIA, under Interagency Agreement No. IAA H-8-76, Project Order No. 4. This work, which was completed in February 1978, covered all significant flooding sources affecting the City of Port Angeles.

The hydrologic and hydraulic analyses for coastal areas of Port Angeles, east of N Street, were studied by CH2M Hill Northwest, Inc., for FEMA, under Contract No. EMW-87-C-2471. This work was completed in July 1989.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Port Angeles, Clallam County, Washington. The area of study is shown on the Vicinity Map (Figure 1).

Floods caused by overflow of Ennis, White, Peabody, Valley, Tumwater, and Dry Creeks were studied in detail. Shallow flooding caused by ponding of runoff was studied in detail, and boundaries were delineated using historic information.

The coastal areas that were studied east of N Street in 1989 include approximately 4.8 miles of shoreline in the incorporated areas of the City of Port Angeles. The study reach extends from the Angeles 2 survey marker on Ediz Hook eastward to a point on the shoreline north of the intersection of Baker Street and 3rd Avenue.

Those areas studied by detailed methods were chosen with consideration given to all proposed construction and forecasted development through 1989.

2.2 Community Description

Port Angeles, the county seat of Clallam County, is located in the northeast part of the county, 65 miles northwest of Seattle, on the Olympic Peninsula, in the northwestern part of Washington. The city was incorporated in 1890 and, in July 1976, was the 24th largest city in the State with a population of 16,506 (Reference 1).

Port Angeles is bordered on the north by the Strait of Juan de Fuca and on the south by the Olympic Mountains. The city is situated on sloping foothills and has a mean elevation of approximately 100 feet. The climate is marine, with an annual precipitation of 25 inches and an average annual temperature of 49°F (Reference 2).

Port Angeles has predominantly loamy soils with from 5- to 15-percent slope formed over moderately compact glacial drift. The higher parts of the drainage basins are covered with thin rocky soils, generally with over 25-percent slope. The soils have

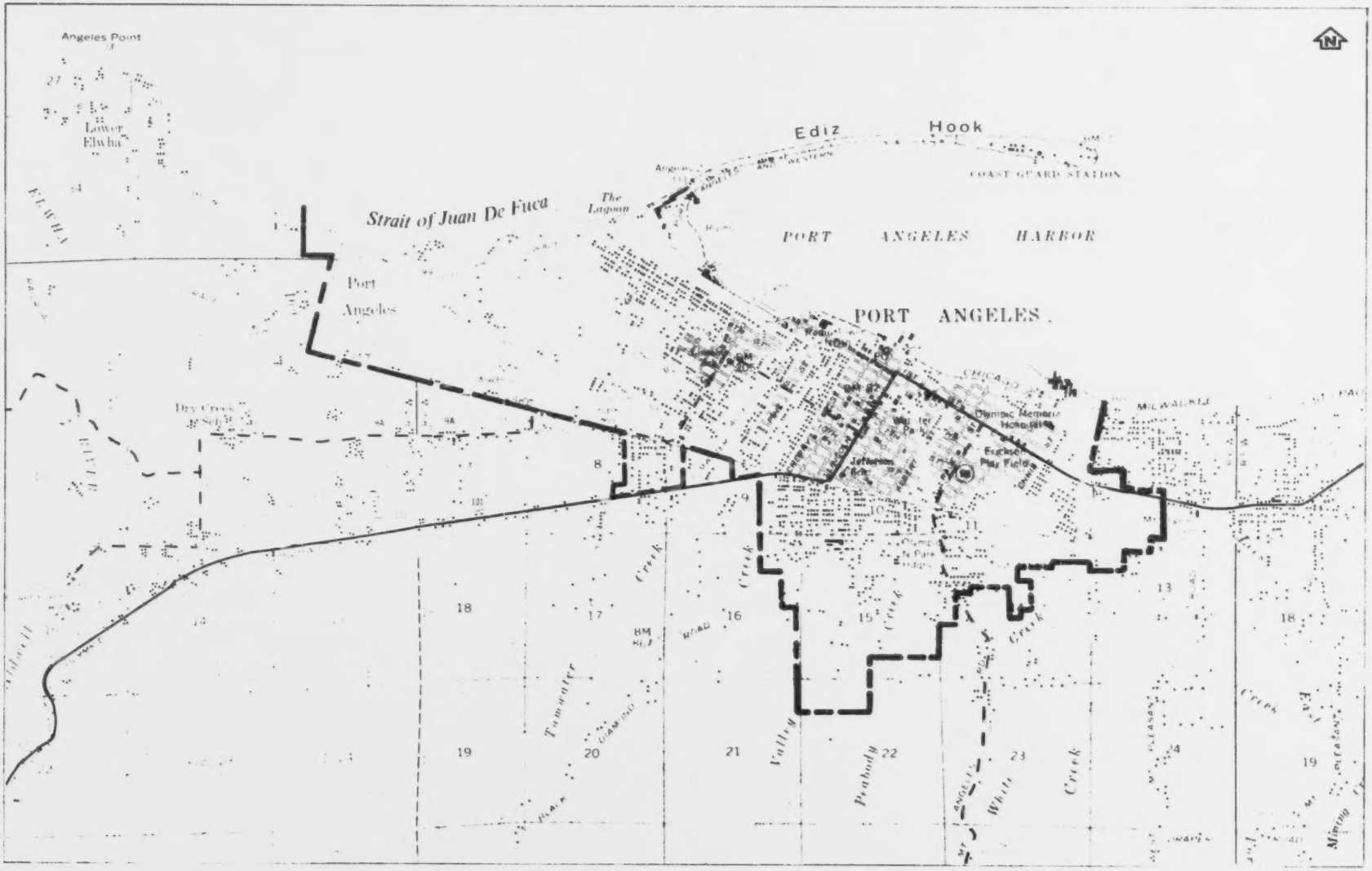

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA

(CLALLAM CO.)

APPROXIMATE SCALE

1 0 1 2 3 MILES

VICINITY MAP

moderate to high permeability and are covered with dense brush, deciduous trees, and conifer trees, except in the business and residential areas.

The floodplains of Port Angeles are located in the lowland along the harbor and contain mostly commercial business structures. The major industries are forestry products and shipping.

Stream drainages are small, with Ennis Creek, at 10.5 square miles, the largest. The channels are steep and confined to deep wooded canyons throughout most of the city. Near the harbor, the channel gradients flatten out appreciably, and overflow occurs.

2.3 Principal Flood Problems

Flooding generally occurs during the winter months, November through February, when storms originating over the Pacific Ocean bring intense precipitation and/or high tides. The major flood problems are those of inundation and damage to private property from out-of-bank floodwaters and storm-driven high tides. The high water during January 1961, a 10-year event, caused some flooding near the mouth of Tumwater and Valley Creeks.

Coastal flooding in Puget Sound occurs when high astronomical tides combined with storm surge produce high stillwater levels. Storm winds associated with high stillwater levels can create waves that propagate onshore, causing additional flood hazards.

The harbor of Port Angeles is sheltered from strong westerly winds directed along the Strait of Juan de Fuca by a natural sand spit (Ediz Hook). However, strong northeasterly winds have caused high waves to develop and enter the harbor, causing heavy wave action along the harbor shoreline. A January 1974 storm generated strong northeasterly winds and damaged docks at the study site. Observation of drift logs and high water marks at the study site indicated the extent of the active surf zone and provided a means for calibrating the flood elevations determined in the study. Discussions with local residents provided additional information on historical storms and flood damage.

There are limited instances of recurring coastal flooding in the harbor area, with the exception of severe historical storm events. Some flooding occurs during heavy rainstorms in the vicinity of the Port Angeles Marina. These problems are attributed to high tide conditions, which restrict flow through drainage systems discharging to the harbor, causing ponding of surface runoff.

2.4 Flood Protection Measures

The Ediz Hook peninsula extends approximately 3 miles into the Strait of Juan de Fuca in a northeasterly direction and can provide shelter for the harbor from strong westerly winds and associated wave action. Heavy wave action, caused by strong northeasterly winds, is significant in the vicinity of the ITT Rayonier Forest

Products plant. Flood protection for the industrial area is provided by a riprap revetment and sheet pile walls near the dock and plant buildings.

High waves entering the harbor west of ITT Rayonier are reduced in height and change direction as shallow water is encountered. In the vicinity of the MV Coho dock and the port of Port Angeles dock, dredging has occurred and higher waves are more likely to break against the shoreline than in other portions of Port Angeles Harbor. The dock areas have riprap revetments and plank and pile seawalls for protection.

Natural beach areas are present at several locations within Port Angeles Harbor. The majority of the beach between ITT Rayonier and the city dock fronts a steep bluff where flood protection as well as potential flood problems are minimal. Natural beaches are also located east of the city dock and northeast of the lagoon at the base of Ediz Hook. No flood protection is evident in these areas, but shallow offshore water causes incoming waves to decrease in height and lessens the effects of wave action.

There are no flood protection works on streams in the area. Flood protection consists of land-use control and regulatory measures.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each stream studied in detail in the community.

Thirteen continuous-record stream gaging stations, with record lengths of 8 to 63 years, and 8 peak-stage-partial record stations, with from 7 to 22 years of peak data, on the Olympic Peninsula (References 3, 4, 5, and 6), were used as the source of data for defining the peak discharge-frequency relationship for each stream in the community. Values of the 10-, 50-, 100-, and 500-year peak discharges were obtained from a log-Pearson Type III distribution of annual peak flow data at these sites in accordance with the guidelines set forth in the U.S. Water Resources Council Bulletin 17 (Reference 7).

Regional relationships in existing publications (References 8 and 9) did not produce satisfactory results for the 10-, 50-, 100-, and 500-year peak discharges in comparison with those obtained for the gaged sites by the log-Pearson Type III distribution. Therefore, new regional relationships of basin characteristics (drainage area and precipitation) to streamflow characteristics (10-, 50-, 100-, and 500-year peak discharges) were developed for determining peak discharges at all sites in the Port Angeles area. These peak discharges have been coordinated with the U.S. Army Corps of Engineers, Seattle District.

Peak discharge-drainage area relationships for streams studied in detail are shown in Table 1.

Analyses were carried out to establish the peak elevation-frequency relationships for tides of selected recurrence intervals for each flooding source studied in detail affecting the community.

Two basic types of events were considered for independent evaluation of coastal flooding. The maximum stillwater flood event considered flood elevations established from recurrence interval stillwater elevations, derived from a frequency analysis of high tide gage records, and combined with wave runup heights caused by winds coincident with the time of the historical high tides. The second type of event, the maximum wind event, considered flood elevations resulting from statistical combinations of recurrence interval astronomical tide elevations, locally generated wind setup heights, and wave runup heights caused by maximum-sustained recurrence interval winds.

For the maximum stillwater flood event, development of the recurrence interval stillwater elevations for the restudy site was based on an analysis of high winter tides (October to March) from the NOAA tide gage 944 4090, located on the port of Port Angeles dock. The short-term record at Port Angeles (1976 to 1986) was extended using a correlation to the monthly high tides at Port Angeles to the coincident monthly high tides at the nearest long-term tide gage, located at Neah Bay, Washington (1934 to 1986). A log-Pearson Type III frequency analysis (Reference 10) was performed to determine the estimated recurrence interval stillwater elevations of the extended record. The resulting recurrence

Table 1. SUMMARY OF DISCHARGES

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cubic feet per second) 10-Year	50-Year	100-Year	500-Year
Peabody Creek					
At Mouth	2.55	149	259	315	463
At U.S. Highway 101	2.09	132	229	278	408
Valley Creek					
At Mouth	4.21	266	451	545	790
At U.S. Highway 101	3.98	254	431	521	755
Above Confluence With Mill Creek	2.86	192	327	395	574
Tumwater Creek					
At Mouth	5.59	374	510	523	550
At Cross Section F[1]	5.59	374	625	752	1,080
At Cross Section O	4.97	336	562	677	973
Dry Creek					
At Cross Section A	5.75	424	699	836	1,190
Ennis Creek					
At Mouth	10.50	613	1,020	1,230	1,770
Above Confluence With White Creek	8.24	519	864	1,040	1,490
White Creek					
At Mouth	2.26	129	226	275	406

[1]Water Flows Out of Channel Between Cross Sections E and F into Shallow Flooding

interval stillwater elevation estimates used in the study are shown in Table 2.

Table 2
SUMMARY OF STILLWATER ELEVATIONS

FLOODING SOURCE AND LOCATION	ELEVATION (feet NGVD) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
STRAIT OF JUAN DE FUCA				
Port Angeles	6.0	6.5	6.7	7.1

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of streams in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each stream studied in the community.

Cross section data for streams in the area were obtained from aerial photographs (Reference 11) supplemented by ground-surveyed cross sections. The underwater segments of all cross sections were obtained by ground survey. All bridges and culverts were surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1).

Roughness coefficients (Manning's "n") for each stream were estimated by field inspection at each cross section. The ranges of "n" values are listed below.

Stream	Channel	Overbank
Ennis Creek	0.040-0.050	0.045-0.060
White Creek	0.040-0.045	0.050-0.070
Peabody Creek	0.038-0.042	0.042-0.055
Valley Creek	0.042-0.044	0.050-0.055
Tumwater Creek	0.042-0.045	0.054-0.060
Dry Creek	0.042	N/A

Water-surface profiles were developed using the USGS step-backwater Program E431 (Reference 12). The 10-year tide was used to develop starting water-surface elevations. Profiles were determined for the 10-, 50-, 100-, and 500-year floods.

No high water marks from previous floods were available for comparison with the computed flood profiles, however, newspaper articles and pictures were available for the January 1961 flood.

The observed water-surface profiles for this 10-year flood were used as a check on areas of shallow flooding and stream flooding for the 100-year flood. Because this flooding was the result of debris blocking culverts on Valley and Tumwater Creeks, the resulting observed water-surface profiles were approximately equal to those of the 100-year flood. The January 1961 peak discharge on Siebert Creek, which is adjacent to Port Angeles, was a 10-year event. From observations by personnel of the Port Angeles Engineering Department, the inundation by the January 1961 event was compared with that of the 10-year event.

Flood Profiles were drawn showing computed water-surface elevations to an accuracy of 0.5 foot for floods of the selected recurrence intervals (Exhibit 1).

Hydraulic analyses were carried out for the maximum stillwater and maximum wind storm events to provide estimates of the elevations of floods of the selected recurrence intervals along the shoreline of Port Angeles Harbor. The analyses considered storm characteristics, and shoreline and bathymetric characteristics of the near shore areas.

Fetch lengths were established for the restudy site based on directions of the high magnitude winds (Reference 13) and the directions of the longest open-water fetches. Waves created in deep water increase in size in relation to open water fetch lengths that the wind can blow across. Determination of estimated fetch lengths used in this study followed procedures described in Reference 14.

Estimates of deep water wave heights generated by winds from the maximum stillwater event required the estimation of an adjusted windspeed, or windstress factor, which represents the surface wind that acts on the water to form the waves. Windstress factors were calculated using the Coastal Engineering Research Center (CERC) computer program MACE-5 (WIND) (Reference 15). Calculations of deep water wave heights were done using the CERC computer program MACE-12 (JONSWAP) (Reference 16), incorporating methods from the U.S. Army Corps of Engineers' Shore Protection Manual (SPM) (Reference 14).

The sheltered waters of the Strait of Juan de Fuca are subject to lower wave heights than the open coast because shorter open-water fetch lengths are available for wave development. Maximum waves in the Strait are therefore generally fetch-limited and occur at a duration coinciding with the earliest occurrence of a fetch-limited wave condition. This condition was determined using graphical methods presented in Reference 17.

The computer program WAVES2 (Reference 18) was used to estimate refraction and shoaling effects of incoming deep water, fetch-limited waves as they approached the restudy site.

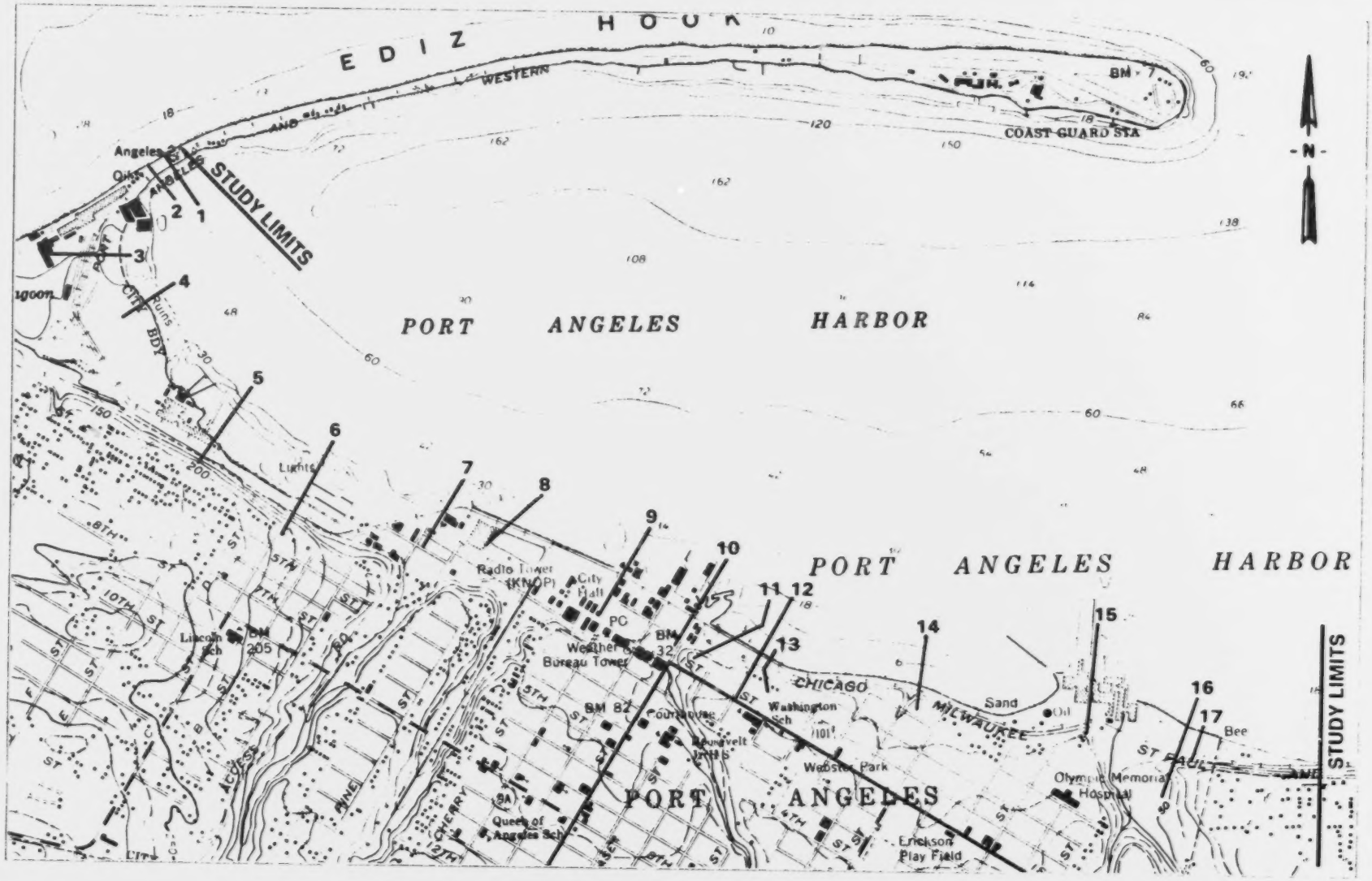

FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

APPROXIMATE SCALE
2000 0 2000 4000 6000 Feet

10 TRANSECT LOCATION MAP: PORT ANGELES

Wave heights and runup were estimated from the refracted deep water waves at transects (cross section lines) as illustrated in Figure 2. The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of changing shoreline characteristics and dense development. In areas having more uniform characteristics, they were spaced at large intervals. It was also necessary to locate transects in areas where unique flooding conditions existed and in areas where wave heights varied significantly between adjacent transects (Table 3). Each transect was taken perpendicular to the shoreline and extended inland to a point beyond probable wave action. The stillwater elevations for the 100-year flood, estimated for both the maximum stillwater and maximum wind events, were used as the starting elevations for wave runup computations.

Beach runup parameters were obtained from the surveyed beach transects. The angle of the seaward beach slopes and the heights of seawalls or berms were measured from plotted survey data.

Runup procedures specified in Reference 19 were used to estimate wave runup. These procedures are based on empirical studies and include the effects of wave setup. Flood elevations for the maximum stillwater flood event were obtained by adding the recurrence interval runup estimate to the same predicted recurrence interval stillwater elevation. Statistical combinations of recurrence interval maximum-sustained wind setup and wave runup with recurrence interval astronomical tide heights were done to determine flood elevations for the maximum wind event. The event producing the higher flood elevation was used to establish the base (100-year) flood elevation (BFE). Estimation of runup heights was verified based on knowledge of the transects from site visits, on understanding the strengths and limitations of the runup procedures, and on engineering judgment.

All elevations are referenced to the National Geodetic Vertical Datum (NGVD) of 1929. Elevation reference marks used in the study are shown on the maps.

Flood elevations in the city are not raised by icejams during spring runoff; however, some flooding does occur as a result of debris blocking culverts. The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are, thus, considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

A primary purpose of the National Flood Insurance Program is to encourage State and local governments to adopt sound floodplain management programs. Each Flood Insurance Study, therefore, includes a

flood boundary map designed to assist communities in developing sound floodplain management measures.

Table 3
PORT ANGELES HARBOR TRANSECT DESCRIPTIONS

Transect	Description	100-Year Base Flood Elevation (feet NGVD)
1	Located along northwest edge of concrete retaining wall containing cylindrical tanks, extending from top of riprap on west edge of Ediz Hook southeast into the harbor	8
2	Approximately 200 feet southwest of transect 1 extending from toe of concrete retaining wall containing tanks, southeast into the harbor	8
3	Located northeast of the lagoon between the former James River Mill and Merrill & Ring Mill, extending from the edge of the lagoon turning east at the center of Marine Drive and into the harbor	7
4	Located along west edge of former Merrill & Ring Mill log dock	10
5	Located just east of the public boat launch and west of Boathaven Marina, extending northeast along pilings and east tip of dock	8
6	Located north of marina building, extending from high point of revetment northeast into the harbor	8
7	Located along west edge of west concrete dock on Port of Port Angeles property	11
8	Located along walkway of abandoned wood structure on riprap revetment east of the main Port of Port Angeles dock	12
9	Located along west edge of Seafarms of Norway dock	13

Table 3 (Cont'd)
PORT ANGELES HARBOR TRANSECT DESCRIPTIONS

Transect	Description	100-Year Base Flood Elevation (feet NGVD)
10	Located at The Landing along east edge of Zarana Fisheries dock	15
11	Located at natural beach area between the Red Lion Inn and the City dock, extending from the intersection of Railroad and Lincoln Streets along railroad tracks and turning eastward into harbor through center of beach	15
12	Located at the southeast edge of the Red Lion Inn, extending across railroad tracks and pipeline into the harbor	15
13	Located within the gully, southeast of the Red Lion Inn, extending northeast near the abandoned trestle railroad bridge	15
14	Located along the base of the shoreline bluff in the vicinity of the north end of Francis Street	17
15	Located along the east edge of the ITT Rayonier dock, extending northward from plant buildings to depth along the dock approximately 200 feet south of the pulp warehouse	19
16	Located on the western edge of the ITT Rayonier sewage lagoon, extending northeast from the base of the wooded hill south of the lagoon, between buildings on plant property and into the harbor	16
17	Located along the north side of the ITT Rayonier sewage lagoon, extending from the top of the lagoon and into the harbor	16

4.1 Floodplain Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FIA as the base flood of purposes for floodplain management measures. The 500-year flood is employed to indicate additional areas of flood

risk in the community. For each stream studied in detail, the boundaries of the 100- and 500- year floods have been delineated using the flood elevations determined at each cross section; between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 2 feet (Reference 12). These maps were developed from aerial photographs at a scale of 1:9,600 (Reference 11).

For each coastal area studied in detail, the 100- and 500-year flood elevation boundaries have been delineated using the flood elevations determined at each transect. Between transects the boundaries were interpolated using topographic maps at a scale of 1:4,800, with a contour interval of 5 feet.

In cases were the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown.

Flood boundaries are indicated on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year flood boundary corresponds to the boundary of the areas of special flood hazards (Zones A1, A2, A3, A4, A11, and V6); and the 500-year flood boundary corresponds to the boundary of the areas of moderate flood hazards (Zone B).

Wave runup heights were estimated to the nearest 0.1 foot, and BFEs were determined at whole-foot increments along the transects (Figure 2). A location on each transect at 3 feet below the runup wave height elevation was used for determining the terminus of the V Zone (area with velocity wave action) for transects having ground profiles sloping upward from the shoreline. A majority of the transects for this restudy have flat or adverse sloped ground profiles, when viewed landward from the shoreline. Establishment of V Zones using the above-mentioned maximum wave runup elevation was not reasonable for these conditions. A wave crest and wave spray transmission analysis was done to estimate a reasonable limit for the V Zone under these ground conditions.

Areas of shallow flooding, between depths of 1 and 3 feet, were designated as Zone AH for ponded water and Zone AO for sheetflow on sloping terrain. Zone AH areas were identified as low lying areas not hydraulically connected to the harbor, but capable of being flooded by waves overtopping high ground between the ponded area and the harbor. Zone AO areas were designated where sheetflow from wave action could occur.

Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; because of limitations of the map scale, such areas are not shown.

4.2 Floodways

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order

that the 100-year flood be carried without substantial increases in flood heights.

No floodway was computed for Port Angeles because the flows were contained in the channels except for distributary flows into shallow flooding at several culverts.

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, the FIA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHFs), and flood insurance zone designations for each flooding source studied in detail affecting the City of Port Angeles.

5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference is not to have a variation greater than that indicated in the following table for more than 20 percent of the reach.

Average Difference Between 10- and 100-year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot

Thirteen reaches meeting the above criteria were required for the flooding sources of Port Angeles. These include one each for Peabody, Tumwater, Ennis, Dry, and Valley Creeks; three on White Creek; and five along the Strait of Juan de Fuca. The locations of the reaches are shown on the Flood Profiles (Exhibit 1).

5.2 Flood Hazard Factors

The FHF is FEMA's device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 1/2 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-

surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the City of Port Angeles was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

Zone A:	Special Flood Hazard Areas (SFHAs) inundated by the 100-year flood, determined by approximate methods; no BFEs shown or FHFs determined.
Zone V1, V2, V3, V4, V5, and V6:	SFHAs along coasts inundated by the 100-year flood, as determined by detailed methods, and that have additional hazards due to velocity (wave action); BFEs shown, and zones subdivided according to FHFs.
Zones A1, A2, A3, A4, and A11:	SFHAs inundated by the 100-year flood, determined by detailed methods; BFEs shown and zones subdivided according to FHFs.
Zone B:	Areas between the SFHAs and the limits of the 500-year flood, including areas of the 500-year floodplain that are protected from the 100-year flood by dike, levee, or other water control structure; also areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

The flood elevation differences, FHFs, flood insurance zones, and BFEs for each flooding source studied in detail in the community are summarized in Table 4.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Port Angeles is, for insurance purposes, the net result of the Flood Insurance Study. Published separately, as part of this study, it is the official map on which FEMA has delineated the flood insurance zones and BFE lines. BFE lines show locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100 - YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10 - YEAR)	2% (50 - YEAR)	0.2% (500 - YEAR)			
Ennis Creek							
Reach 1	0003, 0005	-1.7	-0.5	0.8	015	A3	Varies - See Map
White Creek							
Reach 1	0005	-0.9	-0.3	0.5	010	A2	Varies - See Map
Reach 2	0005	-5.7	-3.5	22.1	055	A11	Varies - See Map
Reach 3	0005	-1.6	-4.0	1.1	015	A3	Varies - See Map
Peabody Creek							
Reach 1	0003, 0005	-0.4	-0.4	0.8	005	A1	Varies - See Map
Valley Creek							
Reach 1	0003, 0004 0005	-1.7	-0.6	1.1	015	A3	Varies - See Map
Tumwater Creek							
Reach 1	0002, 0003 0004	-1.0	-0.4	1.1	010	A2	Varies - See Map
Dry Creek							
Reach 1	0001	-2.1	-0.9	0.3	020	A4	Varies - See Map

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

FLOOD INSURANCE ZONE DATA

CITY OF PORT ANGELES, WA (CLALLAM CO.)

ENNIS CREEK - WHITE CREEK - PEABODY CREEK - VALLEY CREEK TUMWATER CREEK - DRY CREEK

FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100 - YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10 - YEAR)	2% (50 - YEAR)	0.2% (500 - YEAR)			
Strait of Juan de Fuca							
Reach 1	0001, 0002						
	0003	-3.0	-0.8	1.5	030	V6	11
Reach 2	0002	-3.0	-0.8	1.5	030	V6	12
Reach 3	0002	-3.0	-0.8	1.5	030	V6	13
Reach 4	0002	-3.0	-0.8	1.5	030	V6	14
Reach 5	0002, 0003	-3.0	-0.8	1.5	030	V6	15
Reach 6	0002	-0.6	-0.2	N/C	005	V1	8
Reach 7	0002	-0.8	-0.3	N/C	010	V2	8
Reach 8	0002	-0.6	-0.2	N/C	005	V1	7
Reach 9	0002	-1.2	-0.4	N/C	010	V2	10
Reach 10	0002	-0.4	-0.3	N/C	005	V1	8
Reach 11	0002, 0003	-1.0	-0.4	N/C	010	V2	8
Reach 12	0003	-1.1	-0.2	N/C	010	V2	11
Reach 13	0003	-1.5	-0.1	N/C	015	V3	12
Reach 14	0003	-1.2	-0.6	N/C	010	V2	13
Reach 15	0003	-2.3	-0.7	N/C	025	V5	15
Reach 16	0003	-1.3	-0.8	N/C	015	V3	15
Reach 17	0003	-2.0	-0.6	N/C	020	V4	15
Reach 18	0003	-2.8	-0.4	N/C	030	V6	17
Reach 19	0003	-2.9	-2.0	N/C	030	V6	19
Reach 20	0003, 0005	-2.3	-1.2	N/C	025	V5	16

[1] Flood Insurance Rate Map Panel [2] Weighted Average [3] Rounded to Nearest Foot

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA (CLALLAM CO.)

FLOOD INSURANCE ZONE DATA

STRAIT OF JUAN DE FUCA

developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

6.0 OTHER STUDIES

A flood insurance study was previously prepared for the City of Port Angeles (effective August 1, 1980), which included a detailed study of coastal areas within the corporate limits (Reference 20). A flood insurance study was also prepared for the surrounding unincorporated areas of Clallam County in 1980 (Reference 21). A restudy of surrounding unincorporated areas of Clallam County was subsequently made effective in 1989 (Reference 22). The more detailed reanalysis consisted of revisions to the coastal flood elevations (typically lower) and to the extent of the velocity zones. Since incorporated areas of the City of Port Angeles were not included in the 1989 reanalysis, restudy of coastal areas within the corporate limits was needed for consistency in results and methods of analysis with surrounding unincorporated areas.

The limits of detailed restudy for Port Angeles do not directly match the limits of previous detailed studies along the Strait of Juan de Fuca. The eastern limit of this restudy has an estimated VE zone elevation of 16 feet NGVD and connects to a Zone V reach from the previous Clallam County study (Reference 22). The western limit of the present study has established a BFE of 8 feet NGVD within the harbor and does not connect directory to VE zones established in previous studies.

This study is authoritative for the purposes of the National Flood Insurance Program; data presented herein either supersede or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Survey, hydrologic, hydraulic, and other pertinent data used in this study can be obtained by contacting the office of the Federal Insurance Administration, Regional Director, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

8.0 BIBLIOGRAPHY AND REFERENCES

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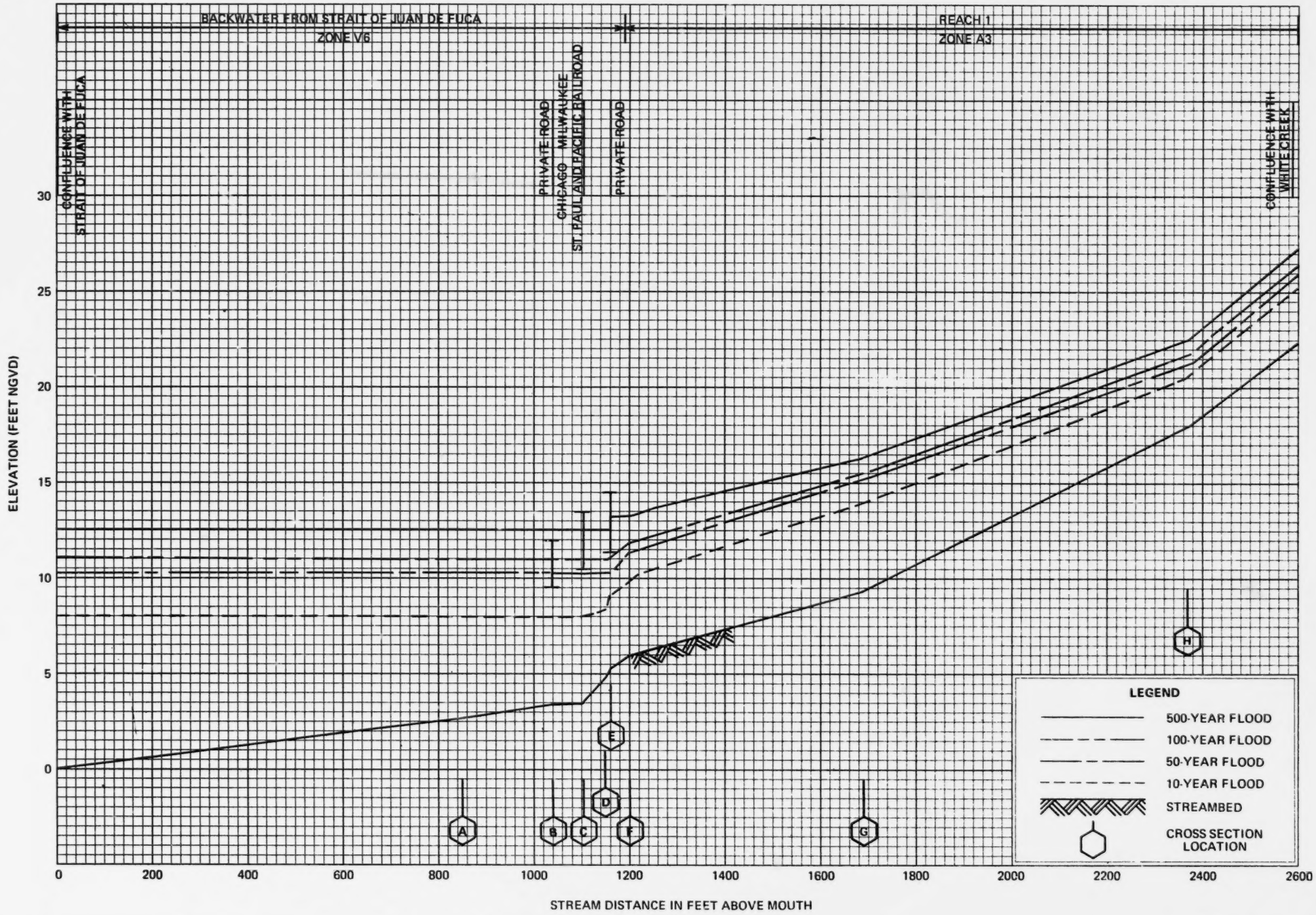


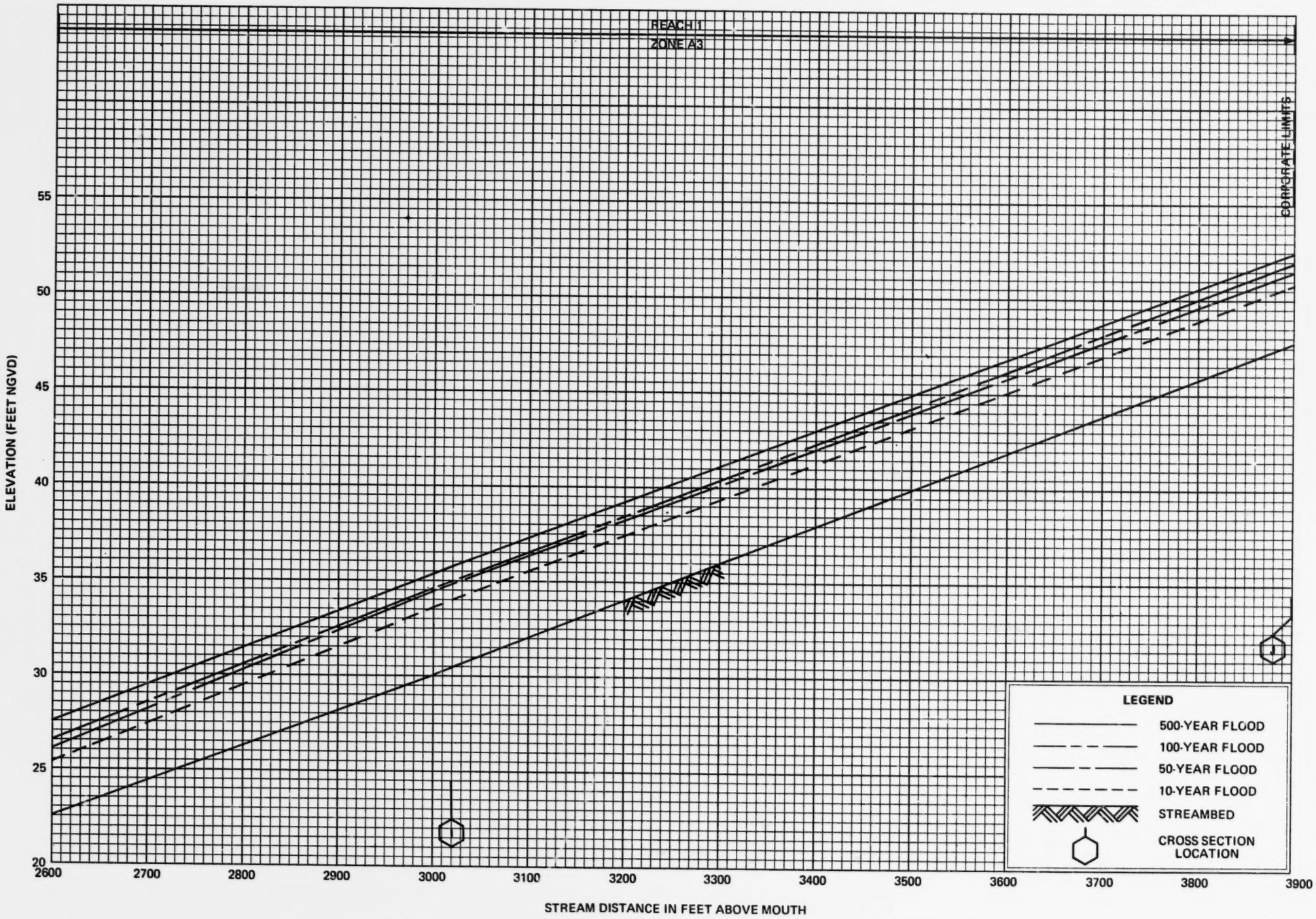
FLOOD PROFILES

ENNIS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

01P



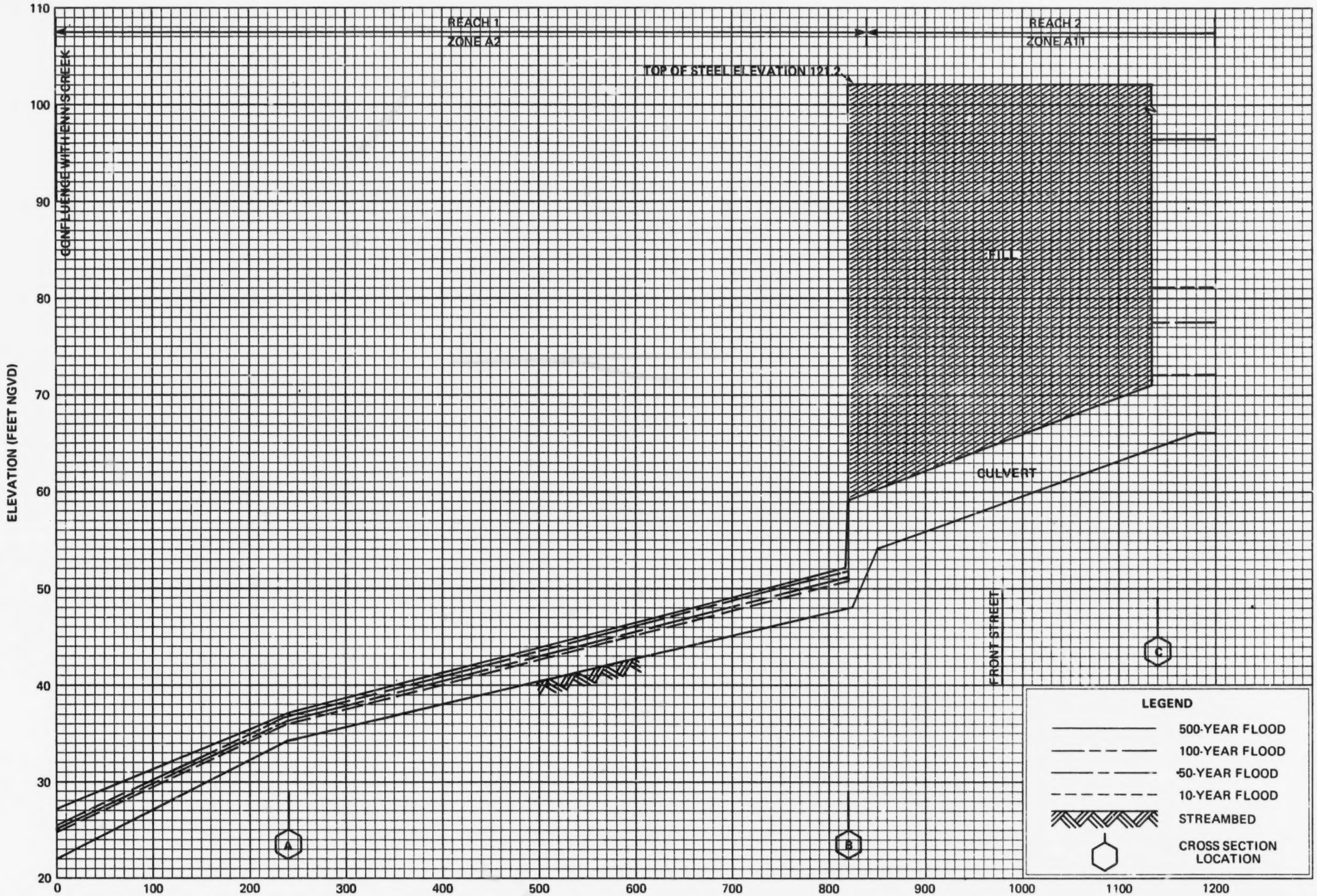
FLOOD PROFILES

ENNIS CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

02P



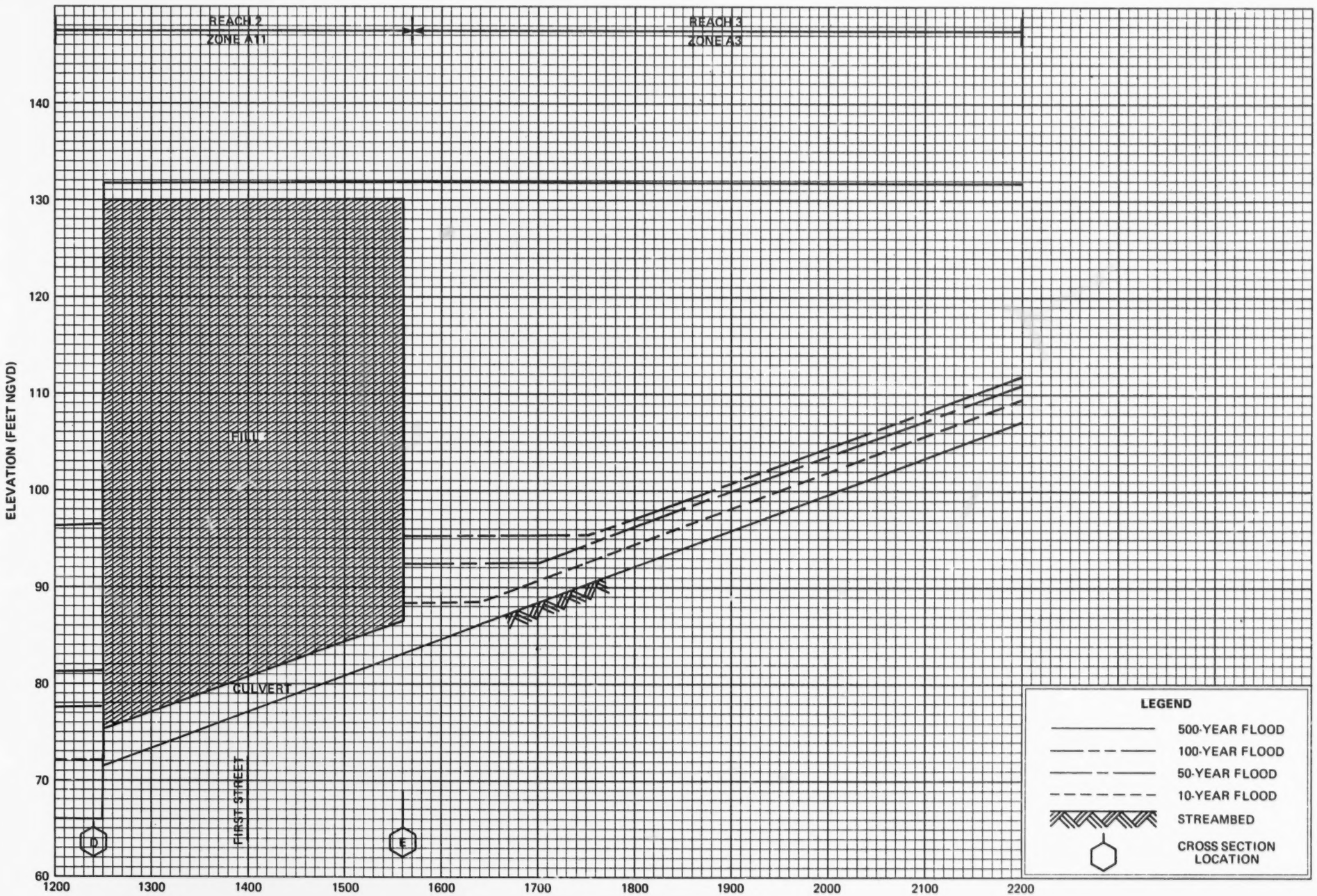
FLOOD PROFILES

WHITE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

03P



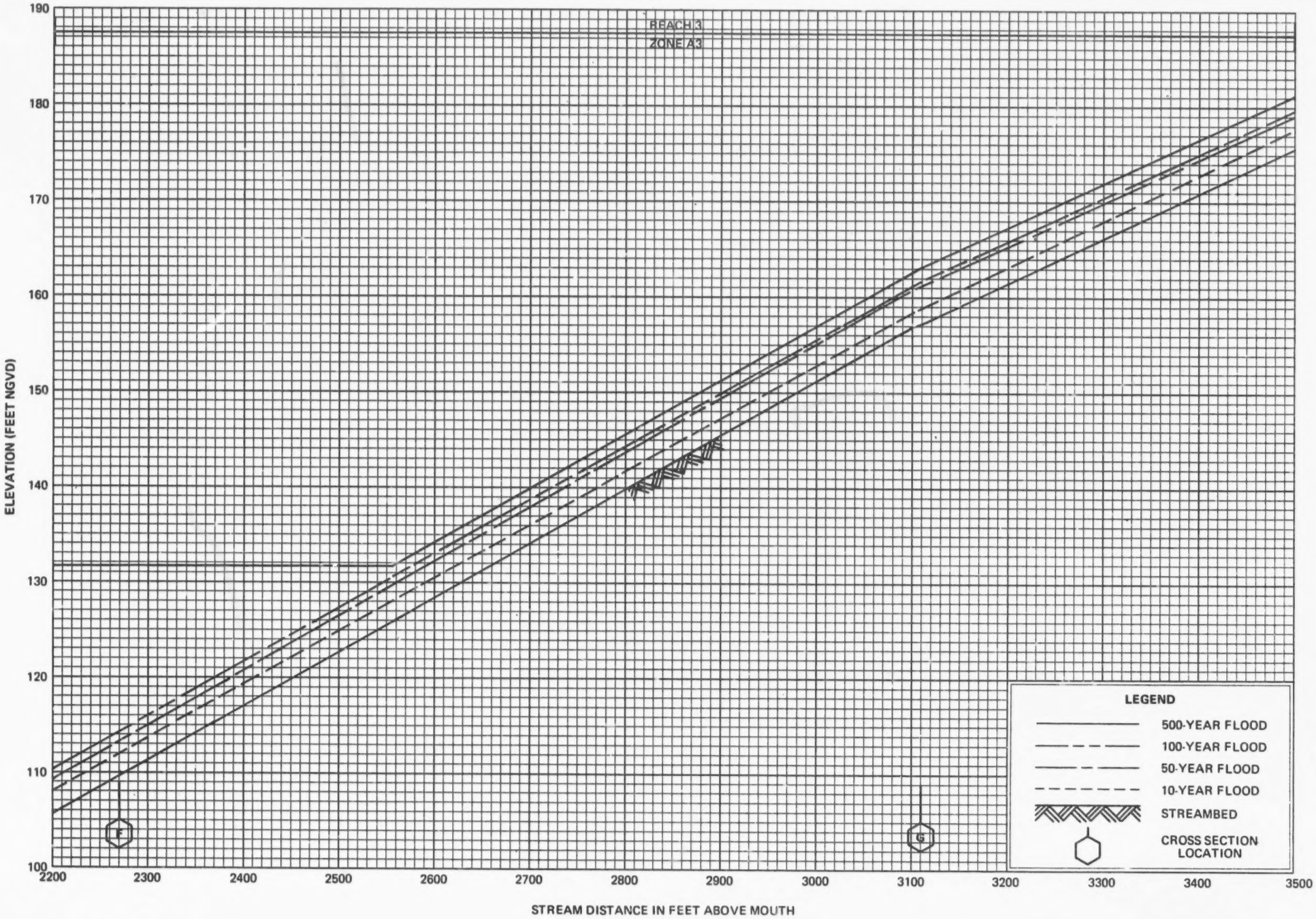
FLOOD PROFILES

WHITE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

04P



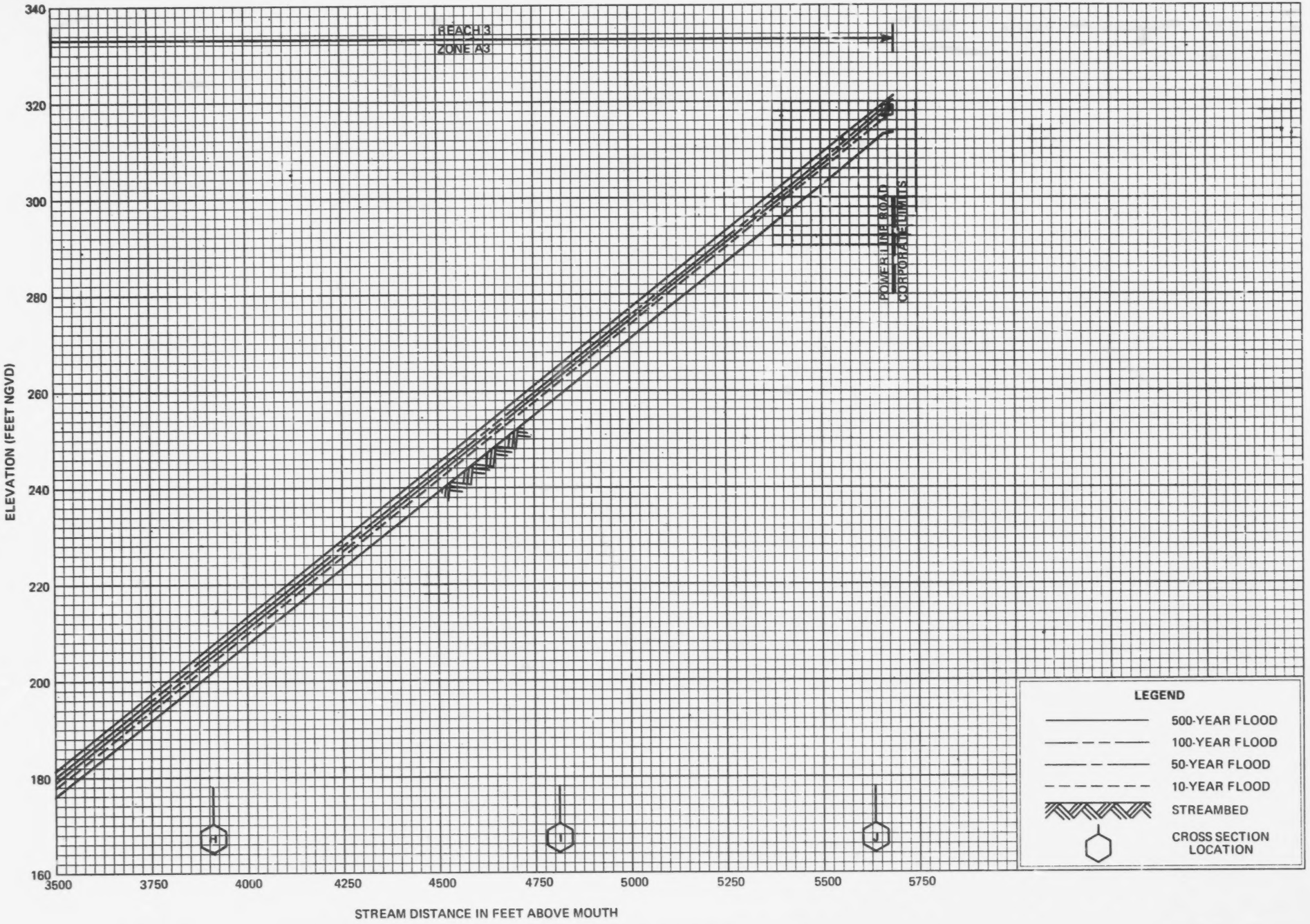
FLOOD PROFILES

WHITE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

05P



FLOOD PROFILES

WHITE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

06P

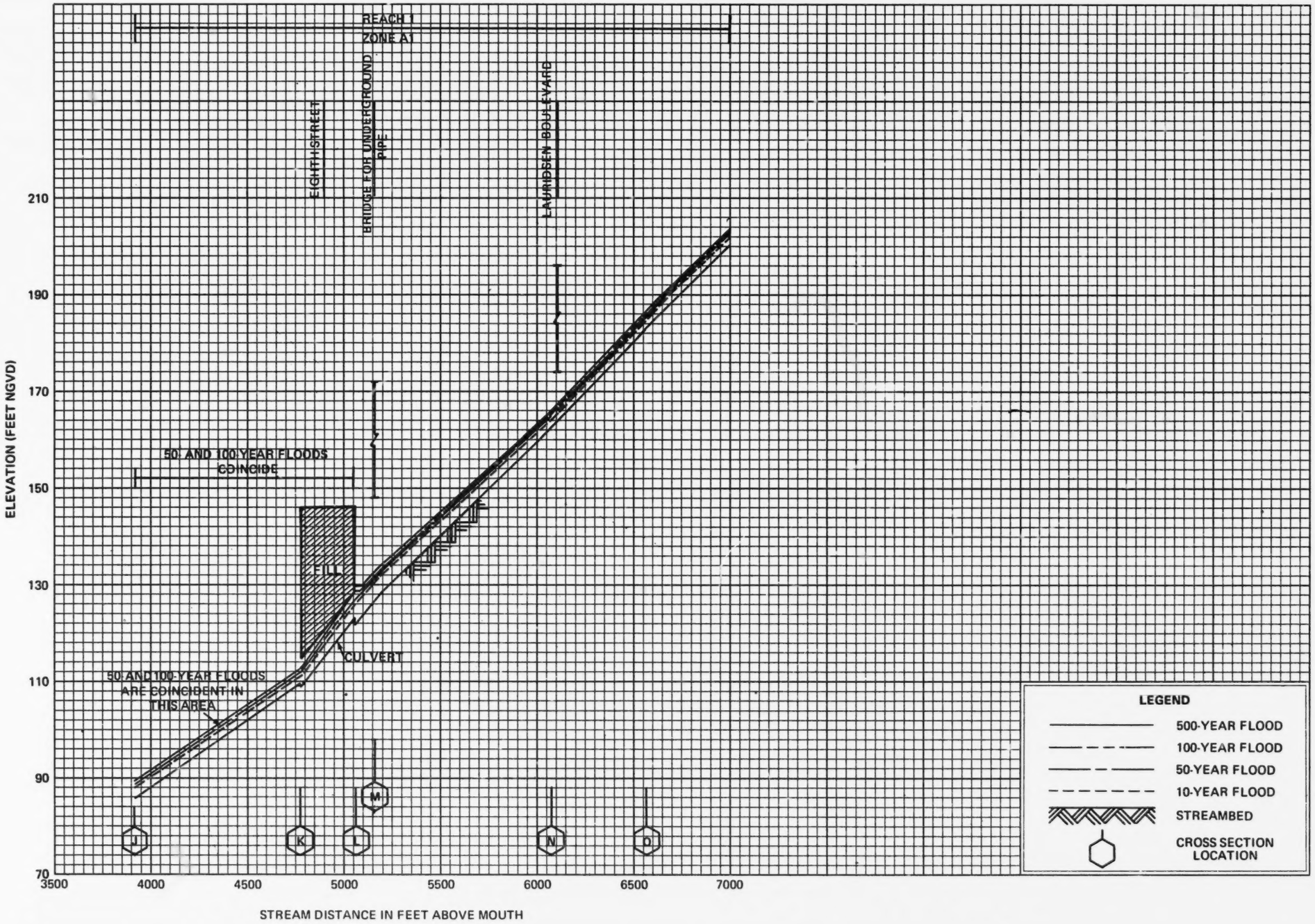
FLOOD PROFILES

PEABODY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

07P



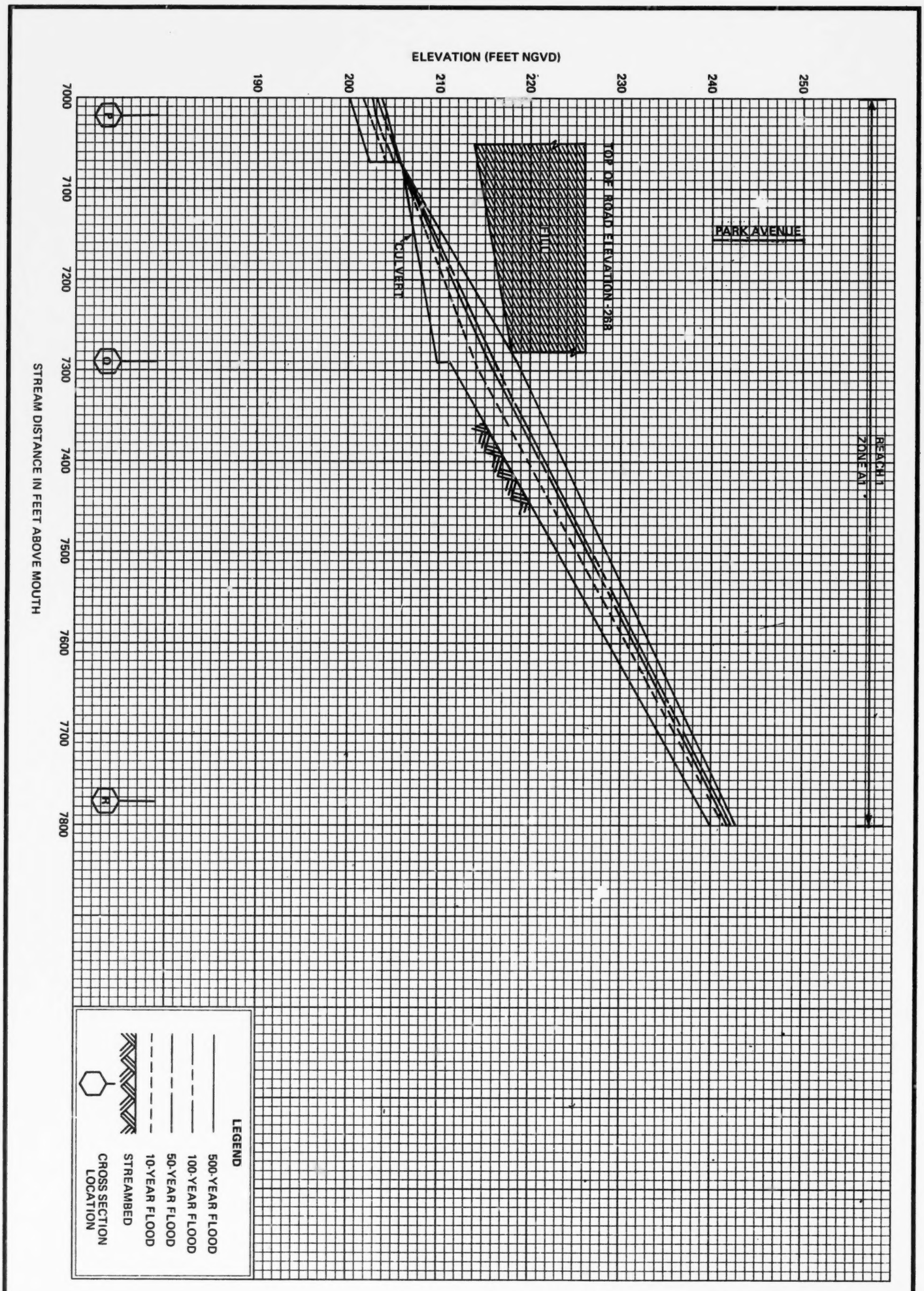
FLOOD PROFILES

PEABODY CREEK

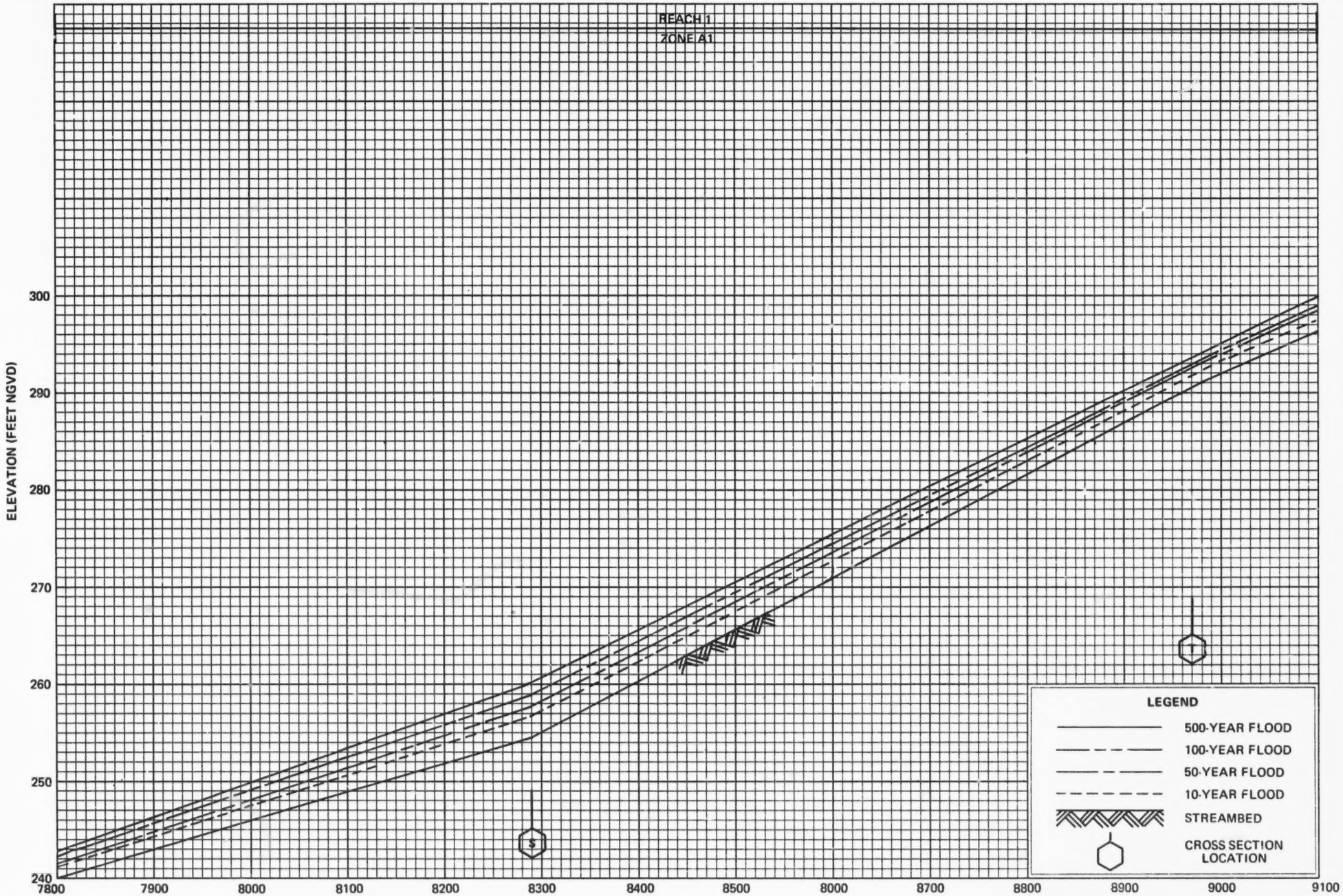
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

08P



09P	FEDERAL EMERGENCY MANAGEMENT AGENCY CITY OF PORT ANGELES, WA (CLALLAM CO.)	FLOOD PROFILES PEABODY CREEK



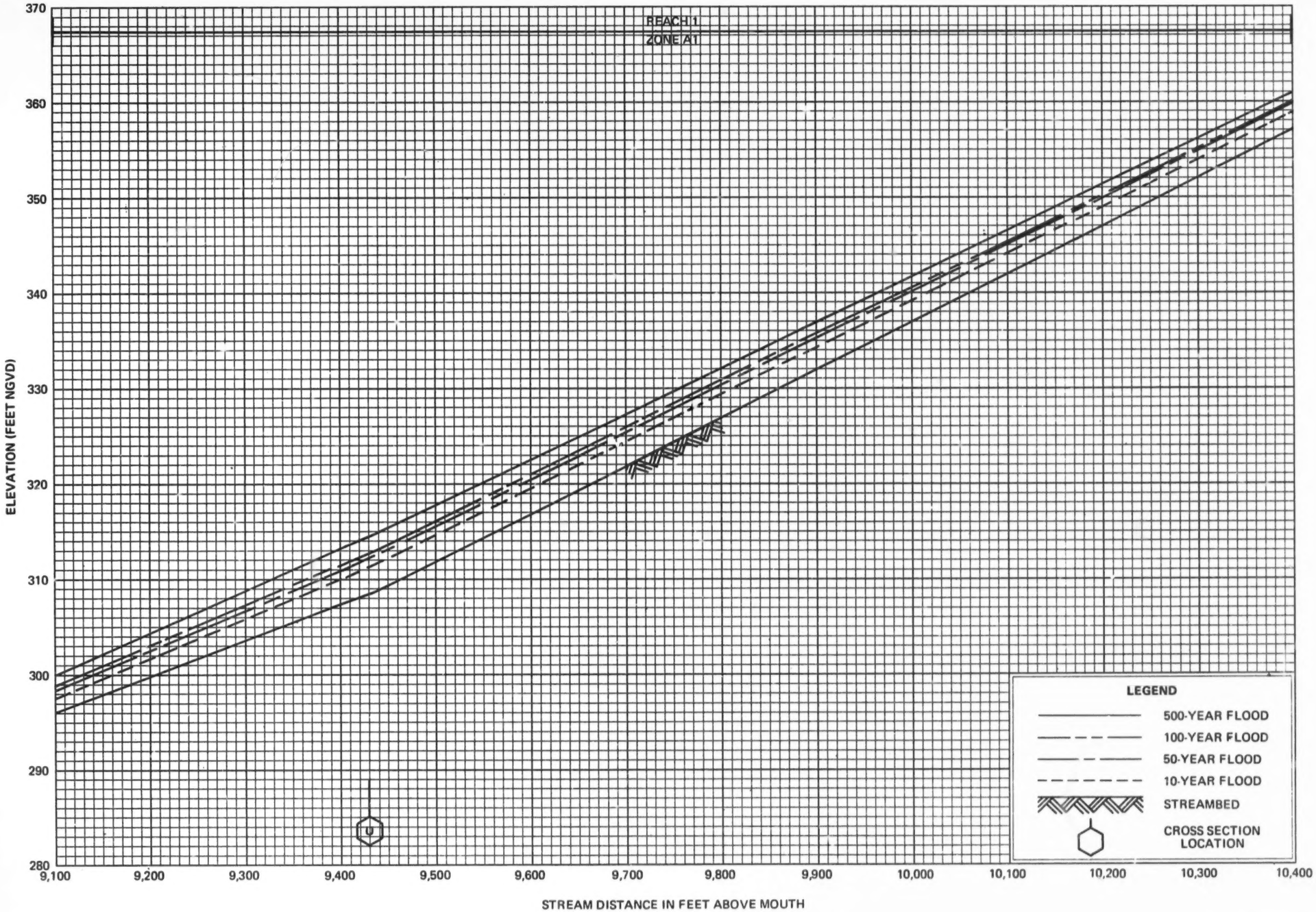
FLOOD PROFILES

PEABODY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

10P



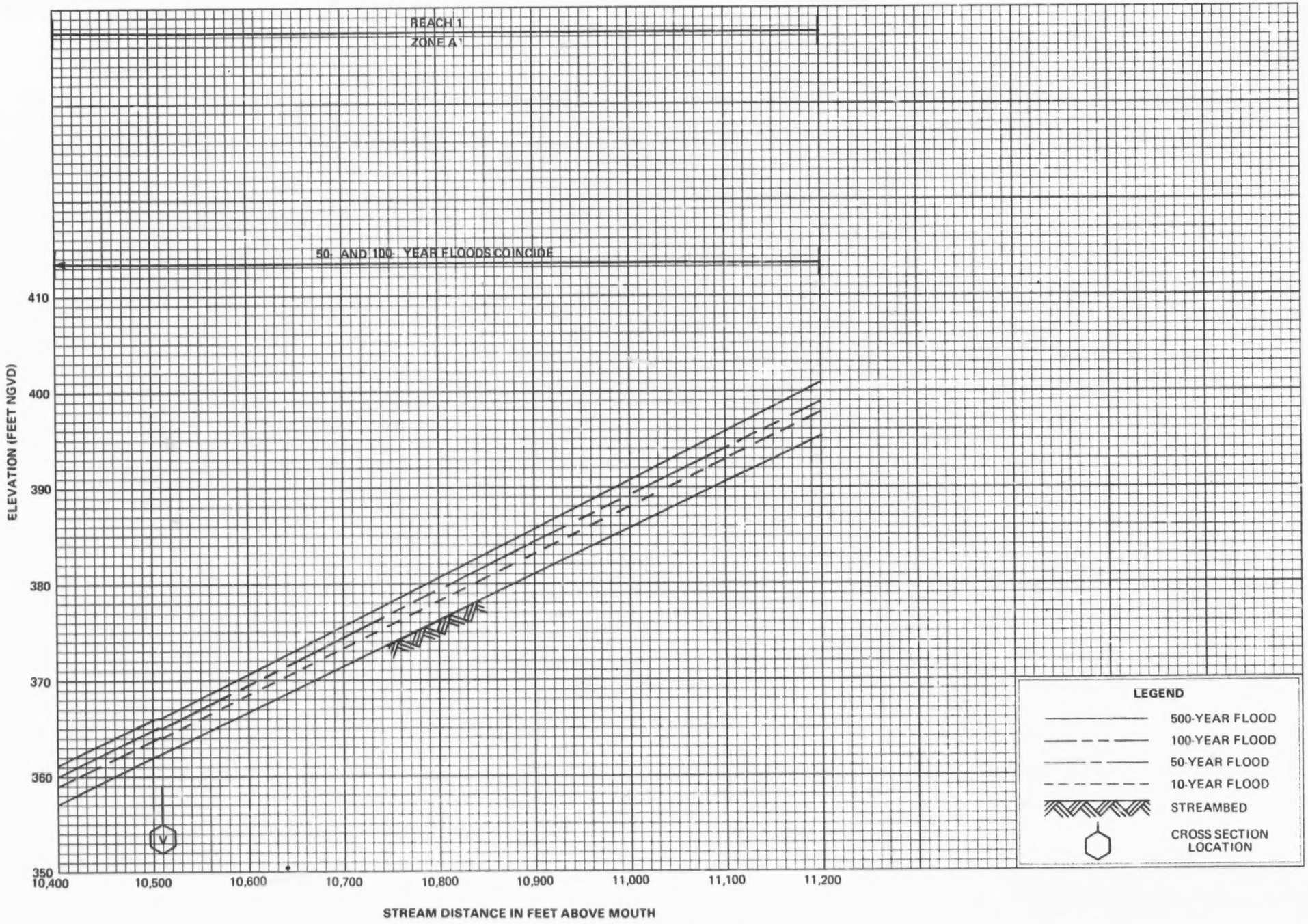
FLOOD PROFILES

PEABODY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

11P



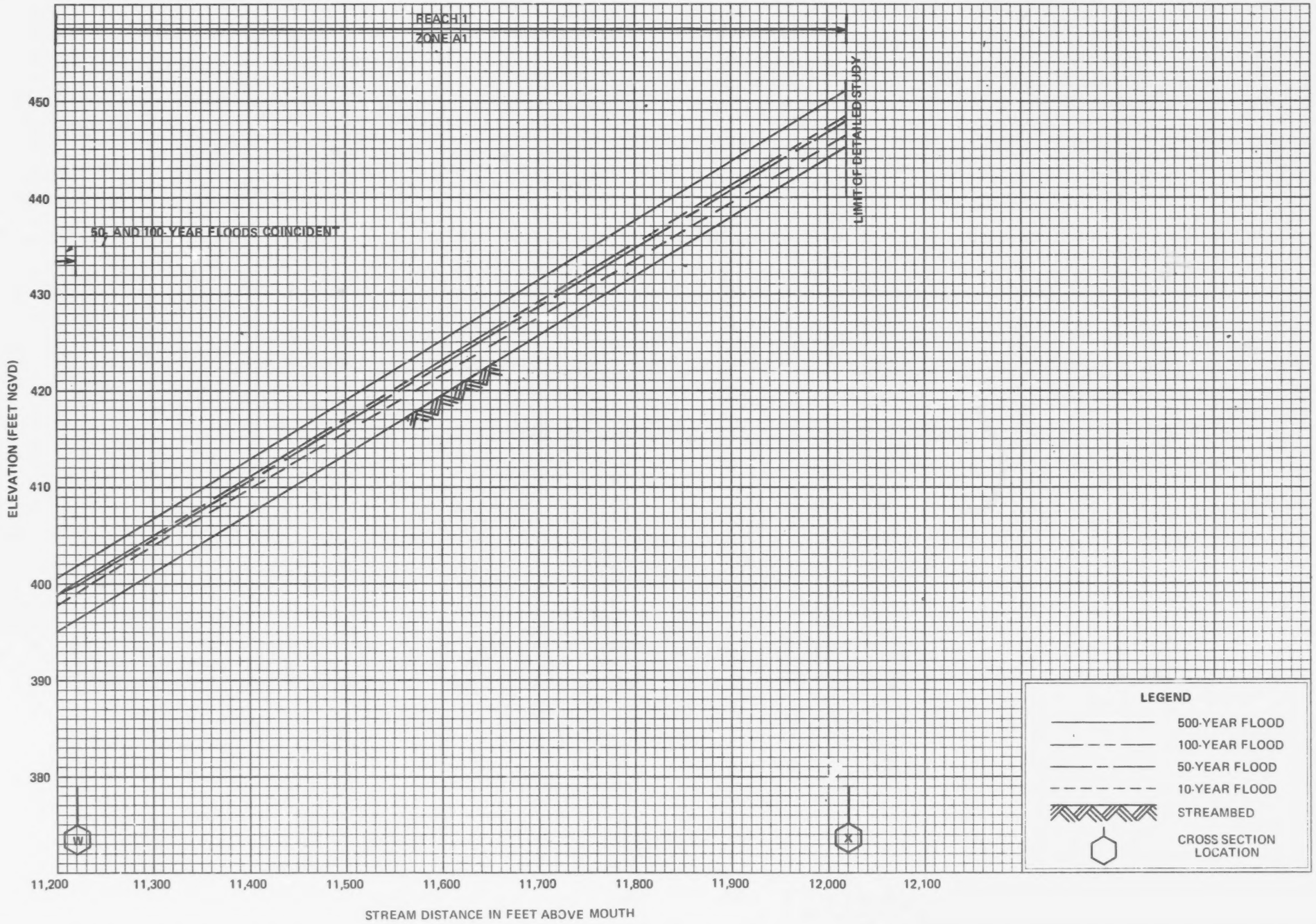
FLOOD PROFILES

PEABODY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

12P



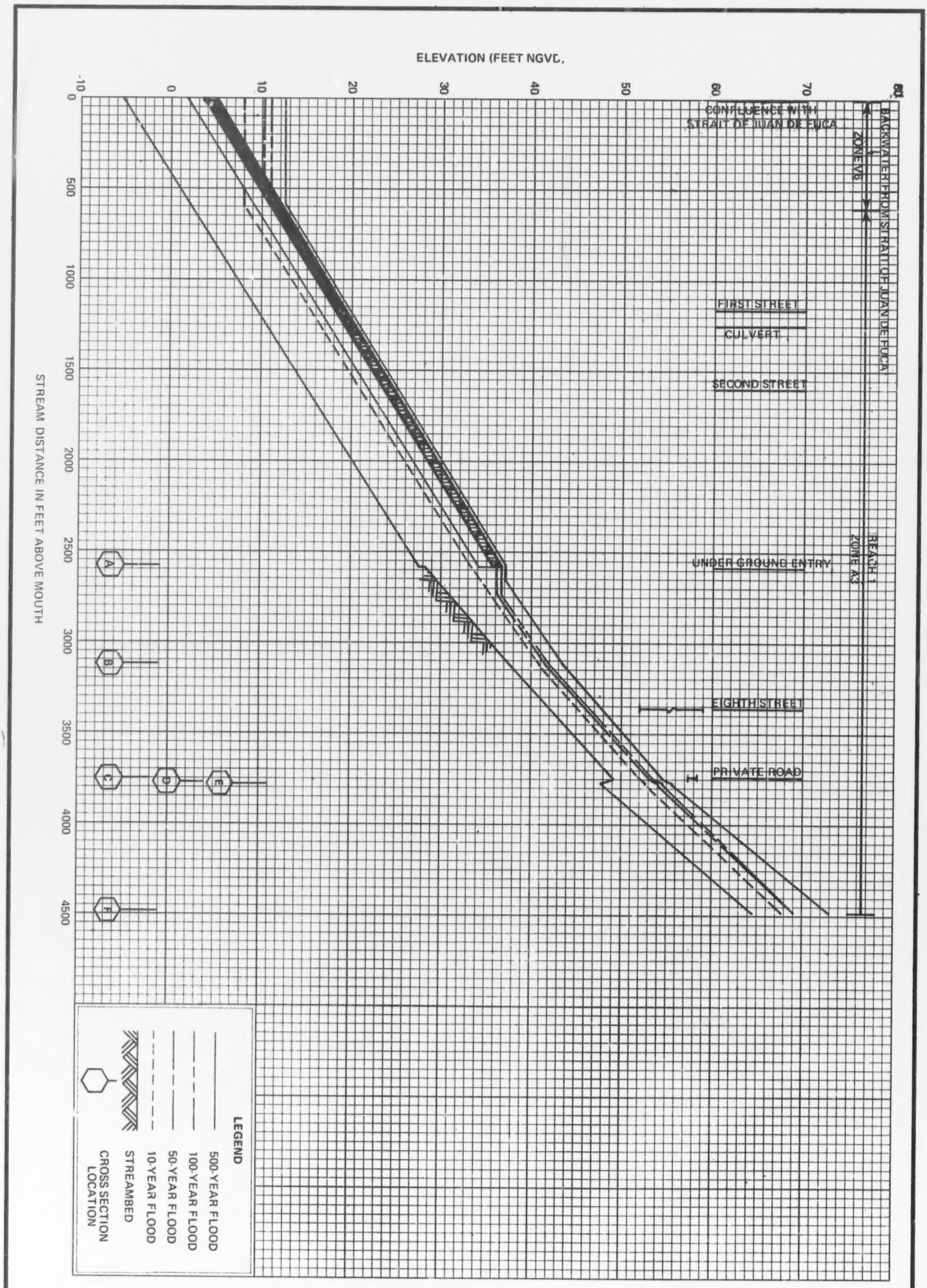
FLOOD PROFILES

PEABODY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

13P



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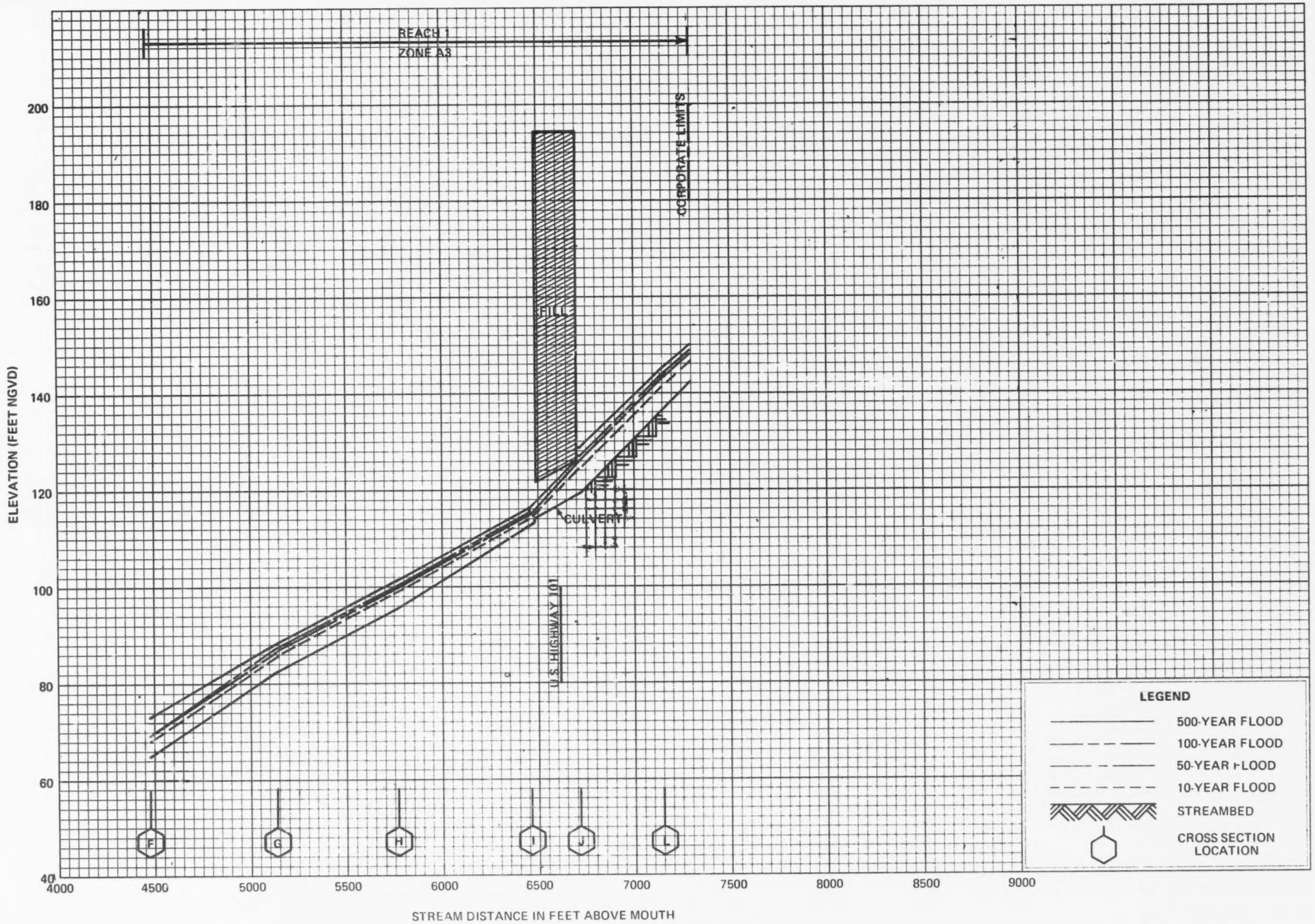


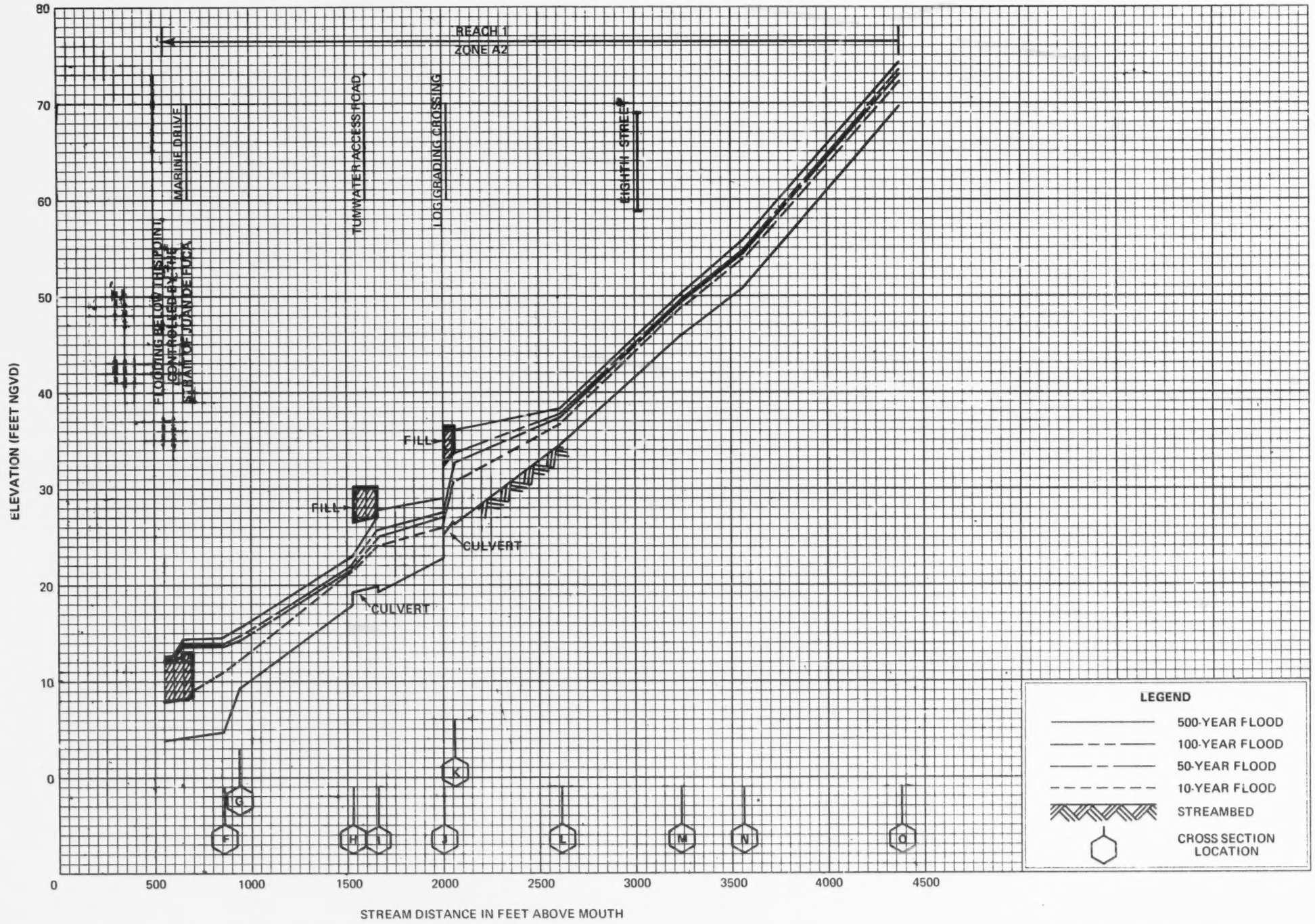
FLOOD PROFILES

VALLEY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

15P



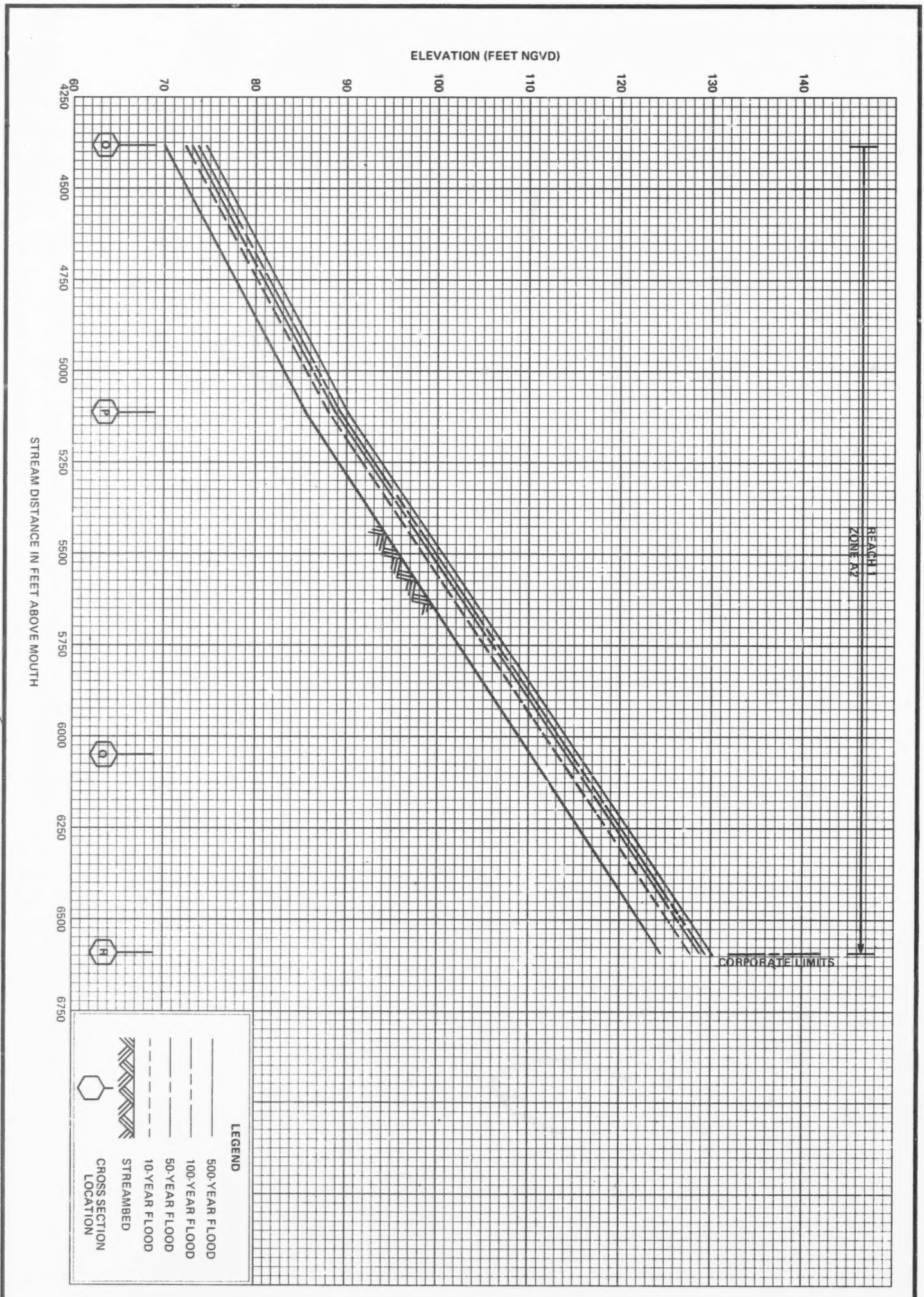
FLOOD PROFILES

TUMWATER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

16P



17P

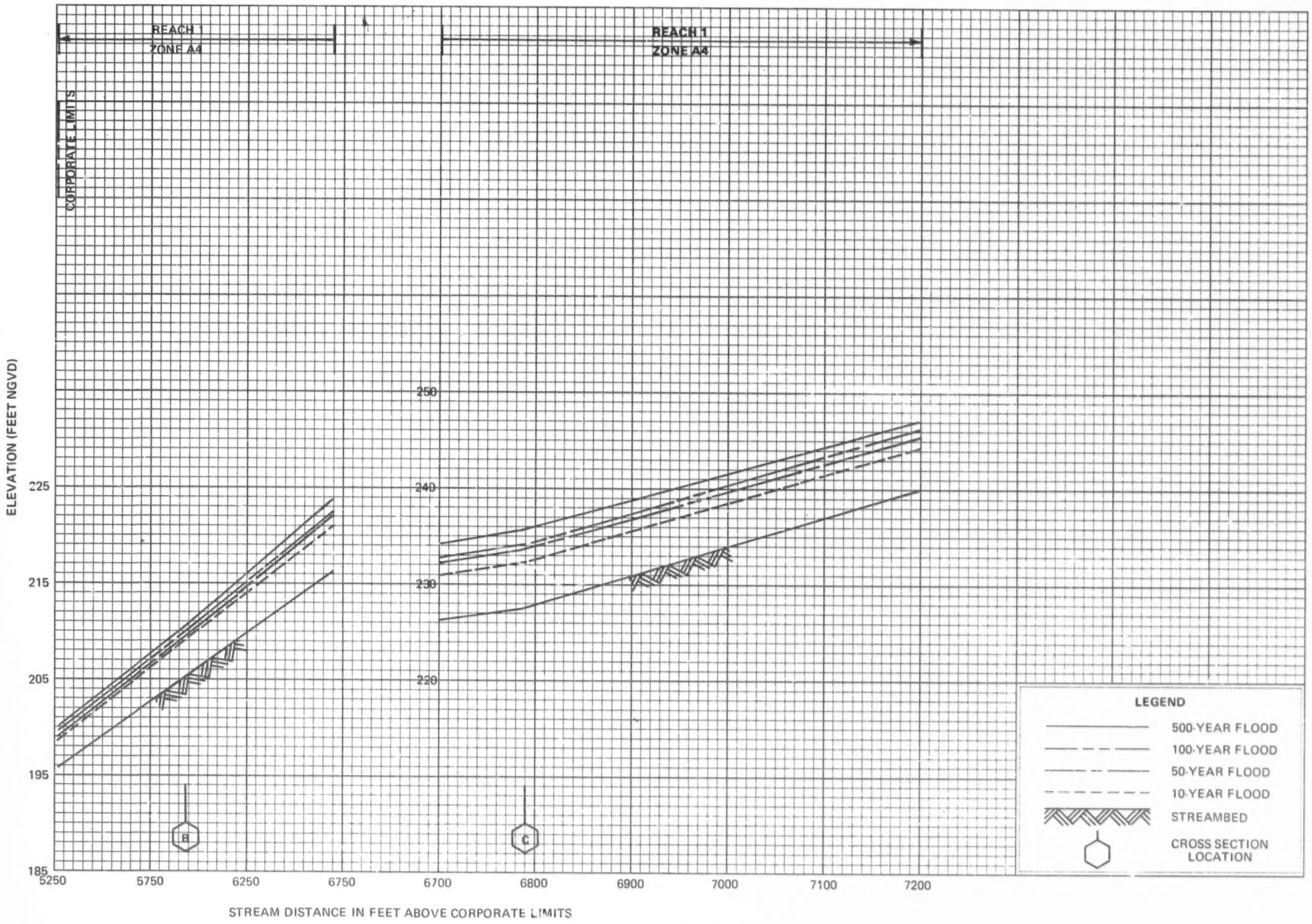
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA

(CLALLAM CO.)

FLOOD PROFILES

TUMWATER CREEK



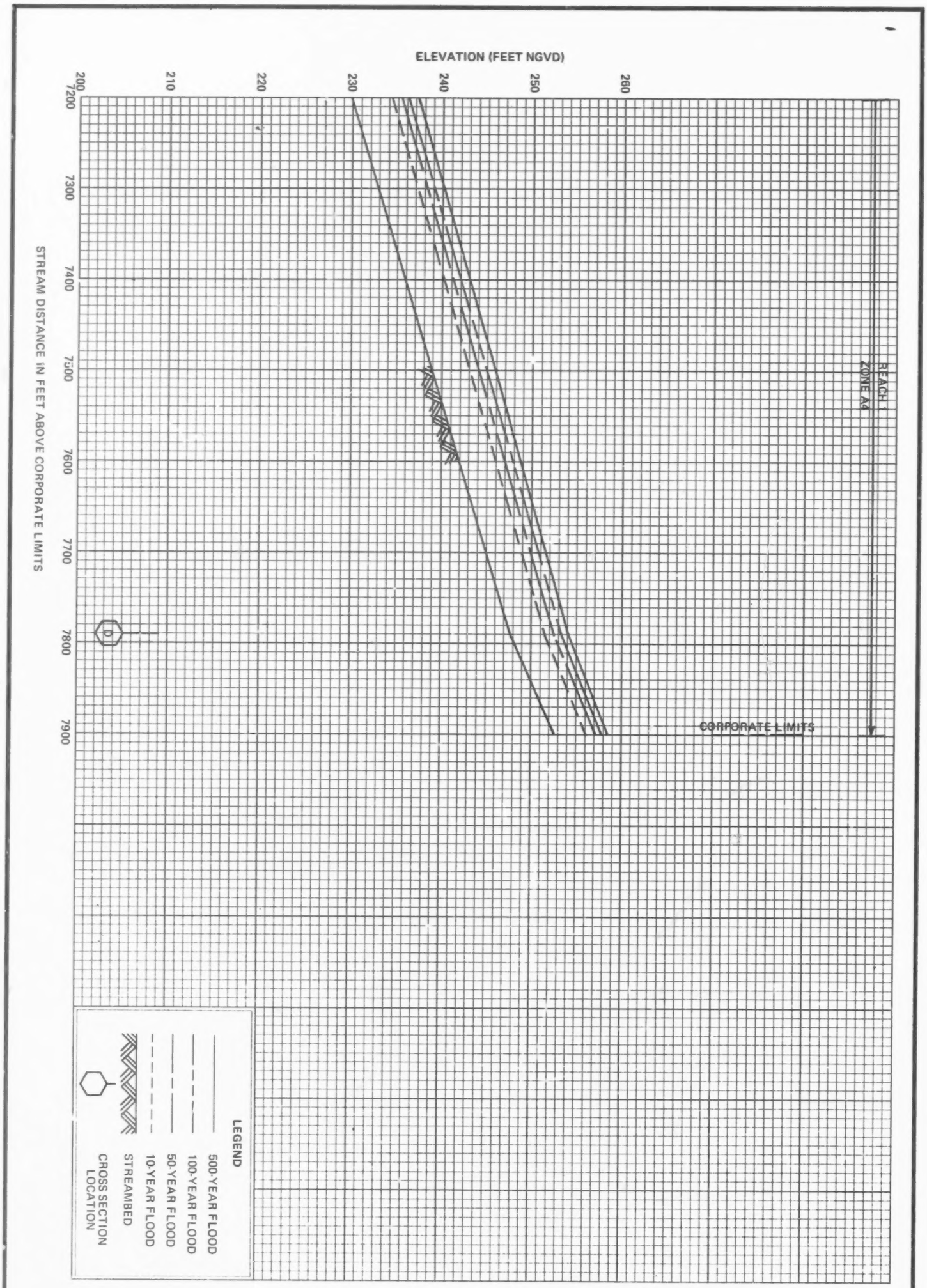
FLOOD PROFILES

DRY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF PORT ANGELES, WA
(CLALLAM CO.)

18P



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